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ARCEUTHOBIUM ABIETINUM SUBSPECIES WIENSII, A NEW SUBSPECIES OF FIR DWARF MISTLETOE (VISCACEAE) FROM NORTHERN CALIFORNIA AND SOUTHERN OREGON

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Abstract

We describe **Arceuthobium abietinum** subspecies **wiensii** (Wiens' dwarf mistletoe, Viscaceae), a dwarf mistletoe that severely parasitizes red fir and Brewer spruce in northwestern California and southwestern Oregon. This classification is based on morphological and host range differences between white fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris*), red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *magnificae*), and Wien's dwarf mistletoe. Male and female plants of Wiens' dwarf mistletoe were consistently smaller than those of both white fir and red fir dwarf mistletoes, whose plants were about the same size. The shoot color of Wiens' dwarf mistletoe was frequently green-brown or red-brown, while the shoot color of white fir and red fir dwarf mistletoes was typically yellow-green or yellow. Differences in host specificity also distinguish Wiens' dwarf mistletoe from white and red fir dwarf mistletoes.

Resumen

Se describe **Arceuthobium abietinum** subespecie **wiensii** (muérdago enano de Wiens, Viscaceae), un muérdago enano que parasita severamente a *Abies magnifica* y a *Picea breweriana* en el noroeste de California y suroeste de Oregon. Esta clasificación se basa en diferencias morfológicas y de hospederos entre el muérdago enano del oyamel blanco (*Arceuthobium abietinum* f. sp. *concoloris*), el del oyamel rojo (*Arceuthobium abietinum* f. sp. *magnificae*), y el de Wiens. Las plantas masculinas y femeninas del muérdago enano de Wiens son consistentemente más pequeñas que las del muérdago enano del oyamel blanco y las del oyamel rojo, las cuales son de tamaño similar entre sí. El color de las ramas del muérdago enano de Wiens fue frecuentemente café verdoso a café rojizo, mientras que el de los muérdagos del oyamel blanco y del oyamel rojo típicamente fue verde amarillo o amarillo. Adicionalmente, el muérdago enano de Wiens se distingue de los otros dos por diferencias en la especificidad de sus hospederos.

Key Words: *Abies concolor*, *Abies magnifica*, *Arceuthobium*, dwarf mistletoe, *Picea breweriana*.

Fir dwarf mistletoe (*Arceuthobium abietinum* Engelm. ex Munz) is a common parasite of white fir (*Abies concolor* (Gordon & Glend.) Hildebrand; including var. *lowiana* (Gordon) A. Murray), and red fir (*Abies magnifica* A. Murray; including var. *shastensis* Lemmon) in the Sierra Nevada Mountains, Cascade Range, and the Klamath and Siskiyou Mountains of northwestern California and southwestern Oregon (Hawksworth and Wiens 1972, 1993, 1996). Fir dwarf mistletoe populations that parasitize white fir in the Sierra Nevada Mountains do not infect red fir, while the fir dwarf mistletoe populations infecting red fir do not infect white fir, yet they are all morphologically similar. Recognizing this distinction, Hawksworth and Wiens (1972, 1996) named two special forms of *A. abietinum*: *A. abietinum* Engelm. ex Munz formae speciales *concoloris* Hawksworth & Wiens, which parasitizes white fir, and *Arceuthobium abietinum* Engelm. ex Munz f. sp. *magnificae* Hawksworth & Wiens, which parasitizes red fir.

Parmeter and Scharpf (1963) were the first to report the extreme host specificity of fir dwarf mistletoe populations based on cross inoculation studies and their field observations in mixed red and white fir stands in the Sierra Nevada Mountains. Although Hawksworth and Wiens (1972, 1996) did not find morphological or phenological differences between the fir dwarf mistletoe populations parasitizing white and red fir, their field observations in the Sierra Nevada Mountains confirmed the host specificity reported by Parmeter and Scharpf. Due to the economic impact that *A. abietinum* has on true firs in California, Hawksworth and Wiens (1972, 1996) argued that since the host affinities of the two fir dwarf mistletoes were so distinct, they deserved taxonomic recognition and designated them as formae speciales in accordance with

recommendation 4B of the International Code of Botanical Nomenclature.

Although Nickrent et al. (2004) suggested a taxonomic classification that treats *A. abietinum* under *A. campylopodum* Engelm. based primarily on molecular data, we reject this alternative classification and adopt the taxonomic treatment for *Arceuthobium* of Hawksworth and Wiens (1972, 1996) which distinguishes *A. abietinum* from *A. campylopodum* using morphological and host range differences between these species. We also agree with Hawksworth and Wiens' (1996) classification of the dwarf mistletoe populations that parasitize Pacific silver fir (*Abies amabilis* Douglas ex J. Forbes) and noble fir (*A. procera* Rehder) in Oregon and Washington as hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosend.) G. N. Jones) although we have determined that two subspecies of hemlock dwarf mistletoe parasitize these true firs to different degrees (Mathiasen and Daugherty 2005, 2007). The subspecies of hemlock dwarf mistletoe that occur on Pacific silver and noble firs can be distinguished from fir dwarf mistletoe by their differences in shoot color and their inability to parasitize red fir (Hawksworth and Wiens 1996; Mathiasen and Daugherty 2005, 2007). Furthermore, white fir dwarf mistletoe does not infect western hemlock (*Tsuga heterophylla* (Rafael) Sargent) although this hemlock is frequently associated with infected white firs in Oregon and grand firs (*Abies grandis* (Douglas ex D. Don) Lindley) in Washington (Hawksworth and Wiens 1996).

In 1996 we were shown a population of dwarf mistletoe severely parasitizing red fir and Brewer spruce (*Picea breweriana* Watson) by Dr. Gregg DeNitto, USDA Forest Service, which occurred near Baldy Mountain northwest of Happy Camp, California (Fig. 1, site 11). Although the dwarf mistletoe plants there resembled fir dwarf mistletoe, plants on both hosts were green-brown or red-brown instead of the typical yellow-green to yellow of fir dwarf mistletoe in the Sierra Nevada Mountains (Hawksworth and Wiens 1996). Furthermore, the dwarf mistletoe occasionally infected white fir indicating it was not *Arceuthobium abietinum* f. sp. *magnificae* (*sensu stricto*). Our examination of another population of dwarf mistletoe parasitizing white fir and Brewer spruce near Flat Top Mountain west of Grants Pass, Oregon (Fig. 1, site 6) also showed the plants at this location were green-brown to red-brown, but otherwise resembled fir dwarf mistletoe. The Flat Top Mountain population had been previously classified as *A. abietinum* f. sp. *concoloris* because white fir was also parasitized there (Hawksworth et al. 1967; Hawksworth and Wiens 1972, 1996). Since the fir dwarf mistletoe on Baldy and Flat Top Mountains infected both red and white firs, as well as Brewer spruce, we began intensive morphological, phenological, and host susceptibility studies of the populations of dwarf mistletoes parasitizing true firs and Brewer spruce in northern California and southwestern Oregon in 1998. Our morphometric analyses and data on host susceptibility differences support the description of a new subspecies of fir dwarf mistletoe.

Arceuthobium abietinum Engelm. ex Munz subsp. **wiensii** Mathiasen & C. Daugherty, subsp. nov. Wiens' dwarf mistletoe.—Type: USA, California, Siskiyou Co., 41°49′21″N, 123°28′05″W. Elev. 1820 m. Klamath National Forest, Baldy Mountain, 18.2 km west of Indian Creek on forest rd. 17N11 (Doolittle Creek rd.), parasitic on *Picea breweriana*, 8 Aug., 2008. *R. L. Mathiasen and C.M. Daugherty 0823* (holotype: ASC; isotypes: JEPS, UNM, US).

Plantae 4–16 (9) cm altae; surculi prinicipales basi 2–6 (3) mm diam.; internodis tertiis 6–27 (14) mm longis, 2 mm latis; fructus maturi 4.2 mm longi, 3.0 mm latis; anthesis mense Julio–Augusto; fructus maturitas Septembri–Octobri. In *Abies magnifica* et *Picea breweriana* parasiticae.

Plants 3.8–16.1 cm in height (mean ca. 9 cm); basal diameter of dominant plants 1.8–5.8 mm (mean 3.1 mm); third internode length 5.6–27 mm (mean 14.0 mm) and 1.9 mm wide (Figs. 2 and 3); staminate plants primarily green-brown, but many red-brown; pistillate plants primarily green-brown, but some red-brown or, rarely, yellow-brown; staminate flowers 3 or 4-partite, flower diameter 2.0–3.8 mm (mean 2.8 mm); mature fruit length 3.1–5.0 mm (mean 4.2 mm) and 2.2–3.5 mm wide (mean 3.0 mm)(Fig. 4). Seeds 1.9–2.9 mm long (mean 2.4 mm) and 0.9–1.5 mm wide (mean 1.1 mm).

Phenology: Anthesis from early July through late August with peaks in late July to early August; seed dispersal from early September to mid October with peaks in late September to early October.

Habit: Principally parasitic on *Abies magnifica* and *Picea breweriana*. Occasionally parasitic on *Abies concolor* and *Abies lasiocarpa* (Hook.) Nutt. Rarely parasitic on *Pinus monticola* Douglas ex D. Don. The host susceptibility classification used here and below is based on the system described in Hawksworth and Wiens (1996).

Distribution: Wiens' dwarf mistletoe occurs in northwestern California from South Fork Mountain (Trinity Co.) north through the Siskiyou and Klamath Mountains into southwestern Oregon on Flat Top Mountain (Josephine Co.)(Fig. 1). Elevational range is from ca 1500 m on South Fork Mountain to as high as 2000 m on Baldy Mountain northwest of Happy Camp, California.

Representative specimens: *Arceuthobium abietinum* subsp. *wiensii*—Paratypes: [all citations

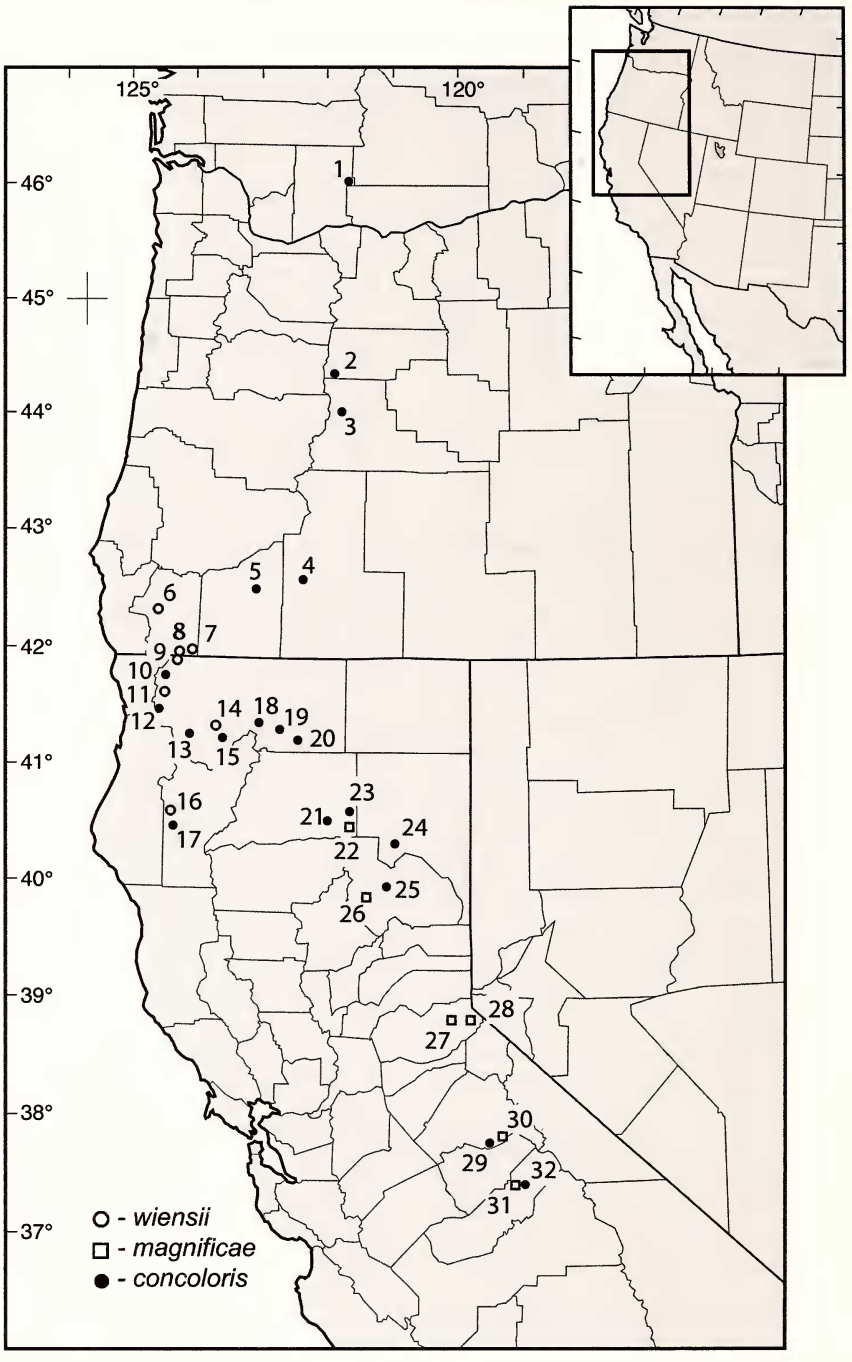

FIG. 1. Approximate locations of populations sampled for *Arceuthobium abietinum* subsp. *wiensii*, *A. abietinum* f. sp. *magnificae* and *A. abietinum* f. sp. *concoloris*. Open circles indicate populations of subsp. *wiensii*, open squares represent f. sp. *magnificae* and closed circles represent f. sp. *concoloris*. Locations: 1—Big Tree rd N of Trout Lake; 2—east side of Suttle Lk.; 3—17 km S of Sisters on rd 16; 4—south boundary of Crater Lake Nat. Park on Rte. 62; 5—1 km E of entrance to Joseph Stewart St. Park; 6—Flat Top Mtn.; 7—Steve Fork Cr.; 8—Althouse Mtn.; 9—Bolan Mtn.; 10—Jct. of Greyback rd and rd to Kelly Lk.; 11—Baldy Mtn. 18 km W of Indian Creek on Doolittle Cr. rd; 12—Rock Creek Butte 41 km N of Orleans; 13—Yellow Jacket Ridge on trail to Chimney Rock Lk.; 14—Etna Summit on rd to Sawyers Bar; 15—3 km N of Eaton Lk. in Russian Peak Wilderness; 16—South Fork Mtn. 20 km N of Rte. 36; 17—South Fork Mtn. 8 km N of Rte. 36; 18—10 km W of Stewart Hot springs on Park Creek rd; 19—1 km W of Black Butte trailhead; 20—10 km W of McCloud on Rte. 89; 21—11 km W of entrance to Lassen Nat. Park on Rte. 44; 22—16 km S of north entrance to Lassen Nat. Park on Rte. 89; 23—17 km SW of

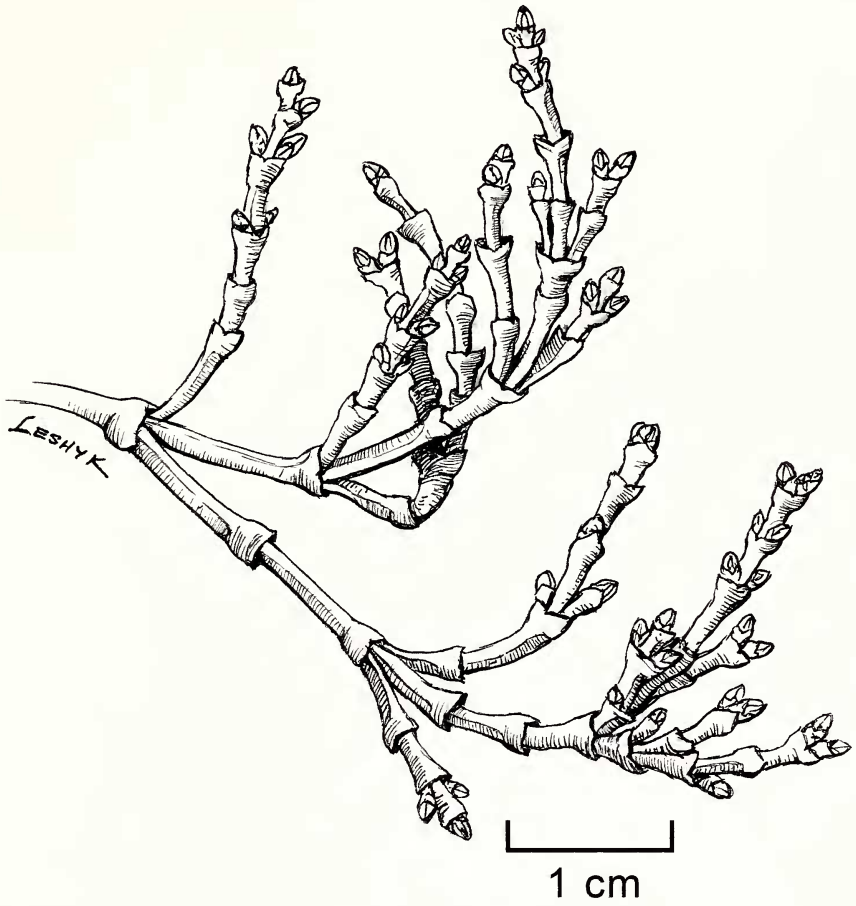

FIG. 2. Male plants of *Arceuthobium abietinum* subsp. *wiensii* in September.

based on *Abies magnifica* except as noted] USA. OREGON. **Josephine Co.**: Flat Top Mountain, on *Picea breweriana*, 2003, *Mathiasen 0357* (♂) (ASC); same site, 2007, *Mathiasen 0741* (♂ & ♀) (ASC); same site, on *Abies lowiana*, *Mathiasen 0742* (♂ & ♀) (ASC) (Fig. 1, site 6); Steve Creek, on *Picea breweriana*, 2003, *Mathiasen 0360* (♂ & ♀) (ASC) (Fig. 1, site 7); Althouse Mountain, 2003, *Mathiasen 0336* (♂ & ♀) (ASC) (Fig. 1, site 8). CALIFORNIA. **Siskiyou Co.**: Bolan Mountain, 2007, *Mathiasen 0743* (♂ & ♀) (ASC); same site, 2008, *Mathiasen 0835* (♀) (ASC) (Fig. 1, site 9); Baldy Mountain, 1998, *Mathiasen 9884* (♂) (ASC) (Fig. 1, site 11); same site, on *Abies lowiana*, *Mathiasen 9883* (♂) (ASC); same site, on *Picea breweriana*, *Mathiasen 9885* (♂) (ASC); same site, 2003, *Mathiasen 0334* (♂) (ASC); same site, on *Picea breweriana*, *Mathiasen 0332* (♂) (ASC); same site, on *Abies lowiana*, *Mathiasen 0333* (♂) (ASC); same site, 2007, *Mathiasen 0746* (♀) (ASC); same site, on *Picea breweriana*, *Mathiasen 0745* (♀) (ASC); same site, 2008, on *Picea breweriana*, *Mathiasen & Daugherty 0823* (♂ & ♀) (ASC) and *Mathiasen & Daugherty 0833* (♀) (ASC); Etna Summit, 2008, *Mathiasen 0830* (♂ & ♀) (ASC) (Fig. 1, site 14); **Trinity Co.**: South Fork Mountain, 2008, *Mathiasen 0865* (♂ & ♀) (ASC) (Fig. 1, site 16).

A total of 7 populations of *Arceuthobium abietinum* subsp. *wiensii* were sampled from within its geographic range (Fig. 1). From each population, 20 to 40 infections were collected and the dominant shoot from each infection was used for morphological measurements. For each population, 10 or 20 male and female infections were collected.

←

Old Station on Rte. 44; 24—13 km SE of rd A21 on Rte. 44; 25—6 km W of Meadow Valley on road to Bucks Lake; 26—Grizzly Summit W of Bucks Lake; 27—1 km E of Lyons Cr. Trailhead; 28—Echo Summit on U.S. 50; 29—9 km W of Crane Flat on Tioga Pass rd, Yosemite Nat. Park; 30—16 km W of Crane Flat on Tioga Pass rd, Yosemite Nat. Park; 31—10 km E of Fish Camp on rd 6S07; 32—11 km E of Fish Camp on rd 6S07.

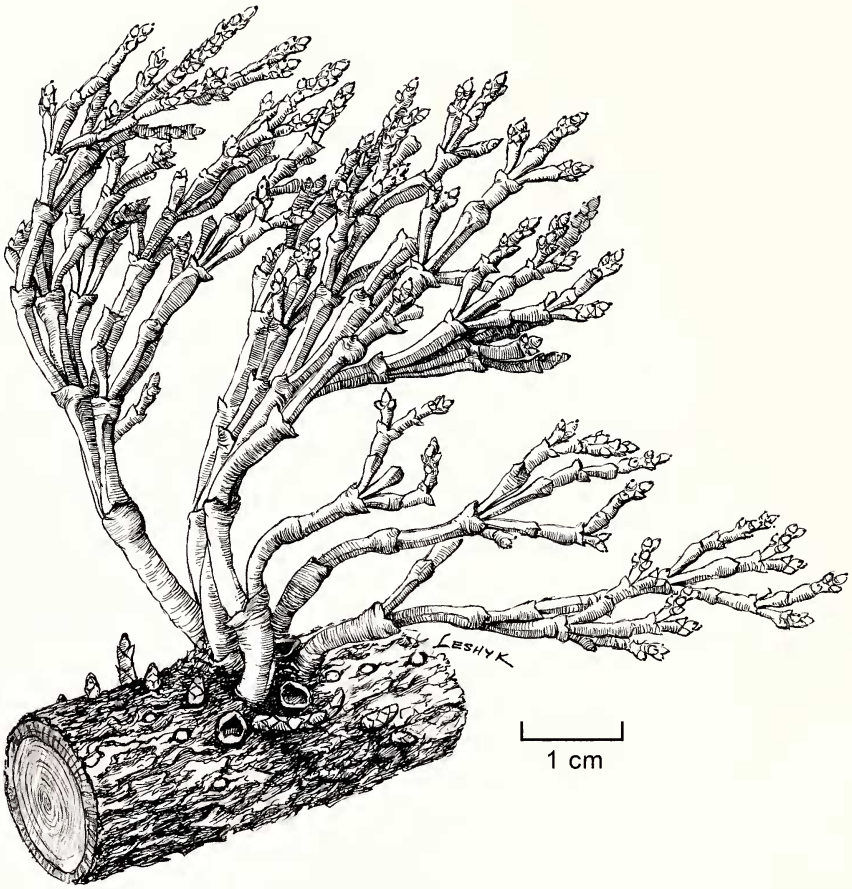

FIG. 3. Female plants of *Arceuthobium abietinum* subsp. *wiensii* in November. These plants have developing fruits that will be mature the following year.

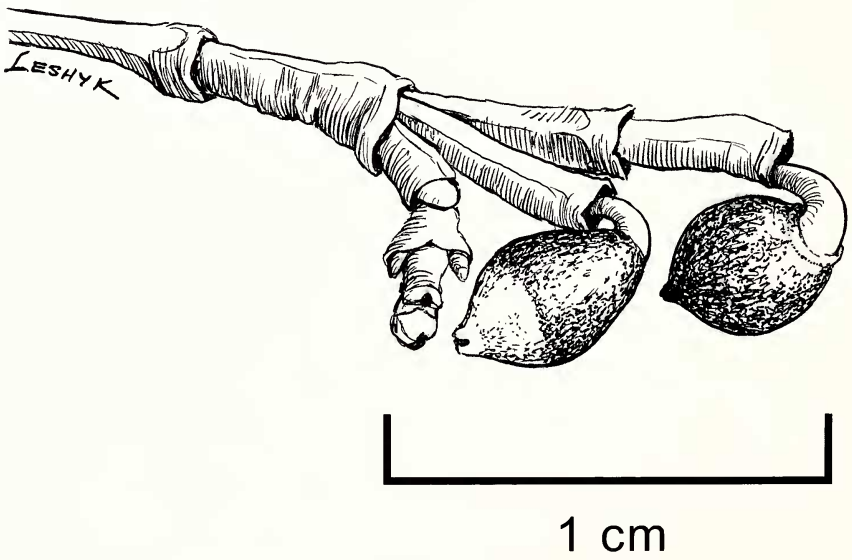

FIG. 4. Mature fruits of *Arceuthobium abietinum* subsp. *wiensii* in October.

In order to make a comparison with the morphological characters of *Arceuthobium abietinum* f. sp. *magnificae* a total of 6 populations of f. sp. *magnificae* were sampled from the central and northern Sierra Nevada Mountains (Fig. 1). From each population, 20 to 40 infections were collected and the dominant shoot from each infection was used for morphological measurements. For each population, 10 or 20 male and female infections were collected. In addition, 20 populations of *Arceuthobium abietinum* f. sp. *concoloris* were sampled throughout most of its geographic range (Fig. 1). From each population, 10 male and 10 female infections were collected and the dominant shoot from each infection was used for morphological measurements.

The dwarf mistletoe plant characters measured were those used by Hawksworth and Wiens (1996) for taxonomic classification. The following morphological characters were measured: height, basal diameter, third internode length and width, and color of the tallest male and female shoot from each infection collected; mature fruit length, width, and color; seed length, width and color; staminate flower diameter; number, length and width of staminate perianth lobes; and anther diameter and anther distance from the perianth lobe tip. Plants were measured within 24 hr after collection and were measured using a digital caliper, a dissecting microscope with a micrometer, or with a Bausch and Lomb 7× hand lens equipped with a micrometer. A minimum of 100 measurements or observations of color were made for each character above. A one-way analysis of variance (ANOVA, $P \leq 0.05$) was used to determine if there were statistical differences between the means of the morphological characters measured.

Plants of *Arceuthobium abietinum* f. sp. *concoloris* and f. sp. *magnificae* were morphologically similar as reported by Hawksworth and Wiens (1972, 1996). Although several morphological characters were similar between the special forms of *A. abietinum* and *A. abietinum* subsp. *wiensii*, there were several consistent morphological differences (Table 1). Male and female plants of subsp. *wiensii* were consistently smaller than those of both f. sp. *concoloris* and *magnificae*, whose plants were about the same size. Differences in plant height were not statistically different between the special forms of *A. abietinum*, but the plant heights of subsp. *wiensii* were different than the plant heights of the special forms for both male and female plants. As noted earlier, the color of plants of subsp. *wiensii* were frequently green-brown or red-brown, while the color of plants of f. sp. *concoloris* and f. sp. *magnificae* were typically yellow-green, or yellow as described by Hawksworth and Wiens (1972, 1996). However, occasionally the female plants, and rarely the male plants of f. sp. *magnificae* were green-brown, particularly at the northern end of its geographic range, but none were red-brown. The reddish-brown to nearly orange color of the plants of subsp. *wiensii* is a distinctive character of this dwarf mistletoe.

Staminate flowers of subsp. *wiensii* were smaller in size (both 3 and 4-merous flowers) than those of f. sp. *concoloris* and f. sp. *magnificae* (Table 1). The mean diameters of both 3- and 4-merous flowers for subsp. *wiensii* were statistically different than those of the special forms. Hawksworth and Wiens (1972, 1996) reported that staminate flower diameters of *A. abietinum* (for both special forms) were 2.5 mm, so this must have been for 3-merous flowers because our measurements of 3-merous flower diameters averaged 2.6 and 2.7 mm for *A. abietinum* f. sp. *concoloris* and f. sp. *magnificae*, respectively. Hawksworth and Wiens did not report flower diameters for 4-merous flowers, but we found that the average diameter of 4-merous flowers was smaller for subsp. *wiensii* (3.2 mm) than for the special forms (3.5 mm). Another character which typically is not informative, but was significantly different between subsp. *wiensii* and the special forms was the distance of the anther from the tip of the perianth lobe. This distance averaged 0.4 mm (range 0.2–0.7 mm) for the special forms, but averaged 0.6 mm for subsp. *wiensii* and some anthers were as much as one mm from the tip of the perianth lobe. This character could often be observed when comparing the anther location on perianth lobes between the special forms and subsp. *wiensii* using a 10× hand lens.

Fruits of *Arceuthobium abietinum* subsp. *wiensii* were smaller on average than those for both special forms (Table 1), but the range in fruit length and width overlapped for all three taxa. However, the mean length of the fruits of subsp. *wiensii* was statistically different than the mean lengths of the special forms, but not the mean width. Furthermore, the color of fruits for subsp. *wiensii* was green-brown to green while the color of fruits for both special forms was consistently green. Seeds of subsp. *wiensii* were also smaller on average than those of the special forms, but the differences were not statistically significant.

The principal hosts of *Arceuthobium abietinum* subsp. *wiensii* were red fir and Brewer spruce, but it is most common on red fir. We presently know of only three locations where it occurs on Brewer spruce; Flat Top Mountain and Steve Creek, Josephine Co., Oregon and Baldy Mountain, Siskiyou Co., California. However, it severely parasitizes Brewer spruce at these locations, but only a few spruces are infected near Steve Creek and the 2002 Biscuit Fire killed most of the severely infected spruce on Flat Top Mountain. However, our observations on Flat Top Mountain and those of Hawksworth et al. (1967) before the Biscuit Fire indicated that many Brewer

TABLE 1. MORPHOLOGICAL MEASUREMENT RESULTS FOR WHITE FIR DWARF MISTLETOE, RED FIR DWARF MISTLETOE, AND WIENS' DWARF MISTLETOE. Data are presented as means with range, and (sample size) below. Means followed by different letters in the same row were significantly different (ANOVA, $P \leq 0.05$). Plant heights in cm; all other measurements in mm. [1]Distance of anther from the tip of the perianth lobe.

Character	White fir dwarf mistletoe	Red fir dwarf mistletoe	Wiens' dwarf mistletoe
Female plants			
Height	12.0 A 7.0–19.6 (200)	11.8 A 5.6–18.4 (100)	9.5 B 3.8–16.1 (130)
Basal diameter	3.7 A 2.3–6.4 (200)	3.6 A 2.4–6.1 (100)	3.2 B 1.8–5.8 (130)
Third internode length	16.0 A 9.3–26.8 (200)	15.8 A 8.1–24.7 (100)	14.7 B 5.6–27.0 (130)
Third internode width	2.2 A 1.5–3.1 (200)	2.1 A 1.4–3.0 (100)	1.9 B 1.3–2.9 (130)
Color	yellow-green/yellow	yellow-green/yellow/green-brown	green-brown/red-brown
Male plants			
Height	12.2 A 6.7–19.4 (200)	11.6 A 7.2–19.2 (120)	8.9 B 3.5–15.7 (160)
Basal diameter	3.6 A 2.2–6.1 (200)	3.5 A 1.9–4.8 (120)	3.1 B 1.9–5.2 (160)
Third internode length	15.9 A 7.0–23.8 (200)	15.4 A 9.9–24.4 (120)	13.5 B 5.4–23.0 (160)
Third internode width	2.3 A 1.6–3.6 (200)	2.2 A 1.6–3.1 (120)	1.9 B 1.4–2.9 (160)
Color	yellow-green/yellow	yellow-green/yellow/green-brown	green-brown/red-brown
Staminate flowers			
Diameter—3-merous	2.6 A 2.3–3.0 (150)	2.7 A 2.4–3.1 (130)	2.4 B 2.0–2.9 (140)
Diameter—4-merous	3.5 A 3.1–4.0 (150)	3.5 A 2.6–4.1 (130)	3.2 B 2.6–3.8 (140)
Perianth lobe length	1.3 A 1.1–1.7 (300)	1.3 A 1.0–1.9 (260)	1.2 A 0.8–2.0 (280)
Perianth lobe width	1.1 A 0.8–1.4 (300)	1.1 A 0.9–1.5 (260)	1.0 A 0.7–1.4 (280)
Anther diameter	0.5 A 0.2–0.7 (300)	0.5 A 0.3–0.7 (260)	0.5 A 0.4–0.7 (280)
Anther distance[1]	0.4 A 0.2–0.6 (300)	0.4 A 0.3–0.7 (260)	0.6 B 0.4–1.0 (280)
Mature fruits			
Length	4.7 A 3.3–5.6 (160)	4.6 A 3.7–5.7 (120)	4.2 B 3.1–5.0 (150)
Width	3.1 A 2.3–4.0 (160)	3.1 A 2.4–3.9 (120)	3.0 A 2.2–3.5 (150)
Color	green, slightly glaucous	green, slightly glaucous	green to green-brown, slightly glaucous
Mature seed			
Length	2.5 A 1.9–3.3 (160)	2.5 A 2.0–3.3 (120)	2.4 A 1.9–2.9 (150)
Width	1.1 A 0.8–1.6 (160)	1.1 A 0.9–1.6 (120)	1.1 A 0.9–1.5 (150)
Color	dark green	dark green	dark green

spruces were severely infected there. Many severely infected Brewer spruces are present on the east slopes of Baldy Mountain as well as many dead spruces killed by the mistletoe.

Wiens' dwarf mistletoe occasionally infects white fir at Flat Top Mountain, Baldy Mountain, Etna Summit, and South Fork Mountain (Fig. 1, sites 6, 11, 14, and 16). It rarely infects western white pine at Flat Top Mountain, but we have not found it parasitizing western white pine at other locations where this tree is associated with severely infected red fir or Brewer spruce. Our observations in the Sierra Nevada Mountains fully support the earlier reports of the host

TABLE 2. PRINCIPAL MORPHOLOGICAL AND HOST DIFFERENCES BETWEEN WHITE FIR DWARF MISTLETOE, RED FIR DWARF MISTLETOE, AND WIENS' DWARF MISTLETOE. Mean plant heights in cm, all other means in mm. [1]Host susceptibility system follows Hawksworth and Wiens (1972, 1996). Host classifications for Wiens' dwarf mistletoe are based on data from field observations. Host classifications for white fir dwarf mistletoe are based on field observations and data presented in Hawksworth and Wiens (1996). Host classifications for red fir dwarf mistletoe are based on data presented in Hawksworth and Wiens (1996).

Character	White fir dwarf mistletoe	Red fir dwarf mistletoe	Wiens' dwarf mistletoe
Mean plant height			
Male	12.2	11.6	8.9
Female	12.0	11.8	9.5
Mean basal diameter			
Male	3.6	3.5	3.1
Female	3.7	3.6	3.2
Mean length of third internode			
Male	15.9	15.4	13.5
Female	16.0	15.8	14.7
Mean flower diameter			
3-merous	2.6	2.7	2.4
4-merous	3.5	3.5	3.2
Mean fruit length	4.7	4.6	4.2
Anther distance from tip	0.4	0.4	0.6
Plant color:			
Male	yellow-green/yellow	yellow-green/yellow/green-brown	green-brown/red-brown
Female	yellow-green/yellow	yellow-green/yellow/green-brown	green-brown/red-brown
Host susceptibility[1]			
White fir	principal host	immune	occasional host
Red fir	immune	principal host	principal host
Brewer spruce	immune	unknown	principal host
Western white pine	rare host	unknown	rare host

specificity of the special forms of *A. abietinum* there. Because subsp. *wiensii* infects both red fir and white fir, it is physiologically and genetically distinct from both of the special forms. Furthermore, at three locations where f. sp. *concoloris* was severely infecting white fir, it did not infect associated Brewer spruce (Fig. 1, sites 10, 12, and 15). The absence of infection of Brewer spruce by f. sp. *concoloris* is further support that it is genetically distinct from subsp. *wiensii*.

The geographic range of subsp. *wiensii* does not overlap with f. sp. *magnificae* and there is a distinct gap in the distribution of these dwarf mistletoes (Fig. 1). We have been unable to locate any infection of red fir near Mt. Shasta or west of there around Mt. Eddy, although red fir is common in these areas. Hawksworth and Wiens (1996) illustrated this geographic gap in their distribution map for red fir dwarf mistletoe (see their fig. 16.6). However, f. sp. *concoloris* is common in these areas (Fig. 1, sites 18, 19, and 20 and see Hawksworth and Wiens 1996, fig. 16.3). Our map (Fig. 1) only includes the locations of populations we sampled during this study and is not meant to replace the distribution map for f. sp. *magnificae* in Hawksworth and Wiens (1996) which illustrates the location of several other populations of this mistletoe.

Although the distributions of *A. abietinum* subsp. *wiensii* and f. sp. *concoloris* overlap, we have not observed any areas where they are sympatric. Incidence of infection of white fir was consistently low (36–47%) in mixed red fir/white fir stands infested with subsp. *wiensii*. In contrast, in stands with f. sp. *concoloris*, incidence of infection of white fir was common (>91%). In addition, f. sp. *concoloris* plants can easily be distinguished from subsp. *wiensii* by plant size and color.

Differences in plant size, geographic distribution, and host range have been the principal characters used to separate subspecies of *Arceuthobium* (Hawksworth and Wiens 1972, 1996; Hawksworth et al. 1992; Wass and Mathiasen 2003; Mathiasen 2007, 2008; Mathiasen and Daugherty 2007) and these are the principal characteristics that distinguish *Arceuthobium abietinum* subsp. *wiensii* from the special forms of *A. abietinum* (Table 2). Because we also found that the morphological similarities between the special forms of *A. abietinum* reported by Hawksworth and Wiens (1972, 1996) are consistent, particularly in the Sierra Nevada Mountains where the special forms are often sympatric, we concluded that describing these populations as subspecies of *A. abietinum* was not appropriate.

Arceuthobium abietinum subsp. *wiensii* is named in honor of Delbert Wiens, ardent student of *Arceuthobium* and one of the principal contemporary architects of the genus. His collaboration with the late Frank Hawksworth spanned over 25 yr during which they described most of the currently recognized species of *Arceuthobium* in Mexico and Central America, as well as several taxa found in California that many botanists and foresters recognize as distinct species (Hawksworth and Wiens 1993; Mathiasen and Marshall 1999, Hansen and Lewis 2000, Geils et al. 2002).

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